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Untangling the root system

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At the plantain packing station, Costa Rica
(M. Bedford, Baobab production)

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Evaluation

Agronomic performance and resistance to black leaf streak of the hybrid 'CRBP-39'

J.-P. Cohan, C. Abadie, K. Tomekpé and J. Tchango Tchango

Plantain, one of the main food sources for the people of central Africa, is subject to numerous production constraints due largely to numerous pests and diseases, including black leaf streak disease (BLSD, caused by the ascomycete fungus *Mycosphaerella fijiensis* Morelet). This is regarded as the most serious leaf spot disease of bananas throughout the world (Pasberg-Gauhl *et al.* 2000) and can cause very heavy yield losses depending on the epidemiological situation (Stover 1983, Fouré *et al.* 1984, Mobambo *et al.* 1993). In commercial plantations, its control requires the intensive use of fungicides which are very harmful to the environment and which increase production costs. Hence it is impossible to use this method in low-income smallholdings. As cultural techniques such as deleafing do not provide effective control, the development

CRBP-39 Bunch (K. Tomekpé).

of plantain hybrids resistant to BLSD is vital to improve the productivity of these farms (Tomekpé *et al.* 1998, 1999). For several years the genetic improvement programme of the Centre Africain de recherche sur bananes et plantains (CARBAP) has concentrated its efforts in this direction. The plantain tetraploid hybrid 'CRBP-39' (*Musa* cv. AAAB, ITC1344), obtained by crossing a triploid female plantain (*Musa* cv. AAB, local variety 'French clair') and a diploid male banana M53, a synthetic hybrid (AA), is one of the results of this work.

The first tests of this hybrid have shown its excellent resistance to BLSD, its good agronomic qualities and its acceptability to the people of Cameroon (Tomekpé *et al.* 1999). However, although tests of resistant hybrids are often made by comparison with their parents treated against BLSD (Vuylsteke *et al.* 1993), they are made less often with an extra comparison with an untreated parent to determine the influence of the BLSD resistance on the performance of the hybrid (Mobambo *et al.* 1993). The experiment which has been set up and is described here has therefore two aims: to confirm the performance of 'CRBP-39' and to determine the yield losses due to BLSD by comparison with those of its female plantain parent 'French clair' treated and untreated against BLSD, in the soil and climatic conditions of the CARBAP research centre.

Materials and methods

The experimental plot set up in Cameroon in July 2001, on CARBAP land in the plain of Moungo, at Njombé, may be described as follows: altitude 80 masl; latitude 4° 35 N; longitude 9° 39 E; a humid equatorial climate with two seasons; annual rainfall 2600 mm; volcanic brown eutrophic soil.

The plants were derived from plants produced by tissue culture at CARBAP. The hybrid 'CRBP-39', untreated against BLSD, was compared with the local variety 'French clair' which in one treatment was treated against BLSD and subjected to deleafing, and in another received no treatment for BLSD, either with fungicide or by deleafing.

The experimental design consisted of randomized blocks. For each treatment there were five replicates of 28 banana plants. To avoid edge effects, only the 10 central plants were monitored, i.e. 50 plants per treatment.

Fungicide application on 'French clair' (treated) were made on the 10 central plants (4 applications, one week after planting then at 3, 6 and 9 months after planting) by watering the ground with 1% triadimenol (triazole, 30g/plant in 1.5 L water) and by spraying the plant (2 applications, 6 and 7 months after planting) with 25% azoxystrobine (strobilurine, 0.01 L in an oil/water mixture of 0.375 L).

The experimental plot was planted at a density of 1666 plants/ha (2m x 3m) and fertilized with 35 g of urea every month (except in the 2nd month when 50 g of sulphate of ammonia was applied) and with 100 g of potassium chloride 4 and 6 months after planting. A nematocidal and insecticidal treatment was applied 3 months after planting using 10% terbuphos (organo-phosphorous) (20 g of product per plant). Weeds were controlled with 36% glyphosate and 20% paraquat.

The following parameters were recorded during the growing phase (every two weeks from the 3rd month after planting), at flowering and at harvest (when the colour of a finger on the 1st hand begins to turn from green to yellow): youngest leaf spotted (YLS), youngest leaf with symptoms (YLWS - the rank of the leaf showing the first symptoms), number of erect leaves (NEL) and infection index (II).

The height of the mother plant and the interval in days between planting and flowering (IPF) were recorded at flowering, whereas the number of functional leaves (NFL - up to 33% or 50% of the surface which is necrotic), the girth of the pseudostem of the mother plant, the height of the sucker and the percentage of necrotic plants were recorded at flowering and at harvest.

The interval in days between planting and harvest, and between flowering and harvest, the weight of the bunch, number of hands per bunch, number of fingers per bunch, finger weight, length of the convex face (measured with a tape measure) and the grade (measured with callipers) of the median finger of the 2nd and 4th hands of the bunch were recorded at harvest. The dry matter content (of peel and pulp after oven-drying at 105ºC for 24 hours) and the hardness of the pulp of the median finger of the 2nd and 4th hand of the bunch (measured with a hand-held penetrometer with a 6-mm plunger) were recorded immediately after harvest when the fingers were still green.

The results were analysed using Statistica® (version 5.5, StatSoft, Inc.) by a two-factor analysis of variance (ANOVA) (including interactions). Means were compared using Newman Keuls' test at the 5% probability threshold.

Results and discussion

Growing phase

The very good resistance to black leaf streak disease of the hybrid 'CRBP-39' compared with the 'French clair' controls is confirmed. The results are shown in Table 1. Six months

after planting, 'CRBP-39' had a mean infection index of 0.5, significantly different from those of the two controls (11.69 for treated 'French clair' and 35.37 for untreated 'French clair'). The difference between the two controls is explained by the fungicide treatment applied to the first.

For statistical reasons the values of YLS recorded six months after planting could not be analysed. Nevertheless one should note the high rank of the latter for 'CRBP-39' (13.44 on average). The YLWS does not however appear to be a useful criterion for characterising the resistance of these varieties to BLSD.

The number of erect leaves was higher for the untreated 'French clair' (11.48) than for treated 'French clair' (8.62). This result may be explained by over-severe deleafing of the latter which reduced the leaf area.

At flowering

Results at flowering are given in Table 2. The almost nil infection index measured on 'CRBP-39' (0.08%) and those measured on the treated and untreated controls confirm the results obtained during the growing phase, namely the excellent resistance to BLSD of 'CRBP-39' and the efficacy of the fungicidal treatments against BLSD on 'French clair'. These conclusions are strengthened by the values of YLS. Finally one should note that 'CRBP-39' had a large number of functional leaves at flowering (13.23 at 33% and 50%), similar to treated 'French clair' - an essential characteristic to assure good development of the bunch and high quality fruit.

The pseudostem girth of the mother plant and the height of the sucker of 'CRBP-39' were significantly greater than those of the controls. The tested hybrid exhibits better agronomic performance at flowering than that of its 'French clair' parent (the untreated 'French clair' seems better than the treated 'French clair' which highlights, in keeping with earlier results (Blomme *et al.* 2001), the influence of regular deleafing on the agronomic performance of the banana plant). The untreated 'French clair' seems to show delayed flowering, in agreement with the results of Mobambo *et al.* (1993), (IPF of 300.31 days) thus indicating the influence of BLSD on the flowering date. However one should treat these results with caution as an analysis of variance was not possible due to the non-normal distribution of residuals.

At harvest

At harvest the hybrid 'CRBP-39' had 5.8 functional leaves whereas its untreated 'French clair' parent had only 0.76 (Table 3). The difference of 10% between the infection index of the two controls can be attributed to the action of the fungicides.

The agronomic performance of the hybrid 'CRBP-39' is again demonstrated (Table 3). In particular, compared with the 'French clair' controls, 'CRBP-39' had bigger bunches (22.36 kg), and more hands (7.54) and fingers per bunch (106.16). On the other hand, the fingers were smaller on average (LCF2 27.81 cm and LCF4 25.79 cm) than those on the controls. There was no difference between fruit weights or between the grades of the median finger.

The treated 'French clair' had a longer planting to harvest interval than the untreated, confirming the accelerating effect of BLSD on fruit maturation. Mobambo *et al.* (1993) had noted the same effect. The data from this mother plant crop do not provide evidence of the influence of BLSD on the bunch weight of 'French clair' (about 19.7 kg whether or not the variety had received fungicide applications). Several hypotheses could explain this fact: 1)

Table 1. Performance of 'CRBP-39' and controls in the vegetative phase (all blocks, 10 central plants) 3 and 6 months after planting.

	'CRBP-39'	'French clair' treated	'French clair' untrated
at 3 months			
YLS	No YLS	6.37a	6.14a
YLWS	2.66b	4.17a	4.11a
NEL [b]	10.16a	8.66b	8.13c
II	0.00b	19.77a	22.03a
at 6 months			
YLS*	13.44	7.51	7.50
YLWS [b i]	3.12c	3.78a	3.44b
NFL [b]	12.04a	8.62c	11.48b
II [b i]	0.50c	11.69b	35.37a

Differences between means of parameters were tested with the Newman-Keuls test at the 5% threshold.
Two means differ significantly if they are followed by a different letter.
[b] indicates that there was a block effect as well as a treatment effect.
[i] indicates that there was an interaction between treatments and blocks.
* residuals were not normally distributed.
YLS: youngest leaf spotted; YLWS: youngest leaf with symptoms; NEL: number of erect leaves; II: infection index.

Table 2. Performance of 'CRBP-39' and controls at flowering (all blocks, 10 central plants).

	'CRBP-39'	'French clair' treated	'French clair' untrated
Disease parameters			
YLS [b]	14**	9.75a	8.86b
NFL 33%	13.23a	12.63a	10.77b
NFL 50% [b i]	13.23a	12.75a	11.13b
NEL [b]	13.45a	13.09b	12.53c
II [b i]	0.08c	10.55b	22.47a
Necrotic plants	4.08%	91.6%	100%
Agronomic parameters			
Girth (cm) [b i]	82.96c	73.51a	76.27b
Height* (cm)	356.78	340.81	356.75
Height on sucker (cm)	164.39b	123.50a	126.97a
IPF* (days)	271.95	296.05	300.31

Differences between means of parameters were tested with the Newman-Keuls test at the 5% threshold.
Two means differ significantly if they are followed by a different lower-case letter.
b indicates that there was a block effect as well as a treatment effect.
i indicates that there was an interaction between treatments and blocks.
* residuals were not normally distributed.
** too few data for analysis.
YLS: youngest leaf spotted; NFL: number of functional leaves; NEL: number of erect leaves; II: infection index; IPF: interval from planting to flowering.

Table 3. Performance of 'CRBP-39' and controls at harvest (all blocks, 10 central plants).

	'CRBP-39'	'French clair' treated	'French clair' untreated
Disease parameters			
YLS	No YLS	1.06a	0.98a
NFL [b]	5.80a	1.80b	0.76c
NEL	6.25a	3.97b	3.12c
II [b]	0.00c	81.00b	91.46a
Necrotic plants	0%	100%	100%
Agronomic parameters			
Girth (cm) [b]	80.46a	71.62c	73.31b
Height of sucker (cm)	277.33a	206.76b	208.01b
Weight of bunch (kg) [b]	22.36a	19.60b	19.75b
Number of hands	7.54a	7.16b	7.24b
Number of fingers	106.16a	89.32b	92.22b
Weight of fruit (g) [b]	192.30a	198.74a	194.84a
LCF2 (cm) [b]	27.81b	31.32a	31.48a
Grade 2 (mm) [b]	50.10a	49.25a	49.58a
LCF4 (cm)	25.79b	28.64a	28.45a
Grade 4 (mm)	49.79a	49.42a	48.65a
IPH (days) [b]	366.05b	378.44a	367.13b
IFH (days)	89.90a	81.80b	79.70b
Fruit characteristics			
DMC 2 Peel	10.88c	12.83a	12.17b
DMC 2 Pulp [i]	32.76c	37.88a	36.83b
Pulp firmness 2 (kg/cm^2) [b i]	2.50c	4.81a	2.82b
DMC 4 Peel	10.54c	12.66a	12.00b
DMC 4 Pulp [b]	32.80c	38.32a	37.01b
Pulp 4 firmness (kg/cm^2)	2.51b	2.96a	2.84a

Two means differ significantly if they are followed by a different lower-case letter.
[b] indicates that there was a block effect as well as a treatment effect.
[i] indicates that there was an interaction between treatments and blocks.
YLS: youngest leaf spotted; NFL: number of functional leaves; NEL: number of erect leaves; II: infection index; IPF interval from planting to flowering; LCF2 and grade 2: length of convex face and grade of median finger of the 2nd hand; LCF4 and grade 4: length of convex face and grade of the median finger of the 4th hand; IPH: interval from planting to harvest; IFH: interval from flowering to harvest; DMC: Dry matter content (2 refers to median finger of 2nd hand, 4 to median finger of 4th hand).

the fertility of the experimental plot might have allowed the untreated control to achieve correct fruit filling despite the influence of BLSD; 2) a natural cleansing of the plot may have occurred due to weather conditions unfavourable to the development of the disease, (dry season); 3) the efficacy of the fungicide applied to the soil might have been low on the volcanic soil of the experimental plot (earlier results indicate that it is effective on lateritic or more clayey soils, Mouliom-Pefoura et Fouré 1988); 4) as no application was made during fruit filling, the treated 'French clair' may have lost the benefit of fungicidal protection compared with untreated 'French clair'.

Generally, the grade 2 of the median fingers of the controls and of 'CRBP-39' (Table 3) is higher than those measured in previous published work (Tchango Tchango *et al.* 1999). This difference could be the consequence of the more intensive cultural practices in this trial.

The measurements made on the median finger of the 2nd and 4th hands show that 'CRBP-39' has a lower dry matter content (DMC 2 pulp and DMC 4 pulp) and a 2 and 4 pulp firmness than those of the treated and untreated 'French clair' controls (Table 3).

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Conclusion

These first results confirm the excellent agronomic performance and resistance to BLSD of the hybrid 'CRBP-39'. The experiment has also shown a delay in flowering and early fruit maturation due to BLSD in the 1st growth cycle. However in the soil and agricultural conditions of Njombé, the differences in growth at flowering between the treated and untreated 'French clair' plantain did not result in differences in yield. The experiment is being continued through the ratoon crop.

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